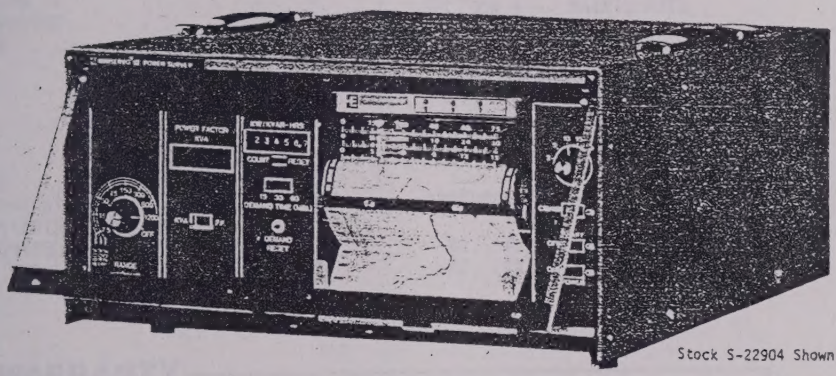
OPERATING INSTRUCTIONS

FOR

MINISERVO® III
POWER SURVEY DEMAND RECORDERS

GE Quick-rental® instruments
THANK YOU FOR ORDERING FROM
1-800-GE-RENTS



Stock S-22904 Shown

SAFETY PRECAUTIONS

Instrumentation described in this document is to be operated indoors and by qualified personnel only. To prevent shock and fire hazards, all electrical connections to the recorder and to measured power lines must be made in compliance with the National Electrical Code (ANSI C1). Always inspect insulation of CTs and input leads; if worn, cracked or chipped, replace before use.

ESTERLINE ANGUS
AN ESTERLINE COMPANY

1. INSTRUMENT DESCRIPTION

1.1 INTRODUCTION

a. Miniservo® III Power Survey Demand Recorders are compact strip-chart instruments specifically designed for measuring, indicating, and recording AC power parameters. The three multirange recorders that are described in this manual include clamp-on current transformers, voltage and current input leads, and disposable ink cartridges for each recording channel. These portable bench-styled units also feature a multispeed chart drive and a NEMA II drip-proof case with self-storing Lexan® front door.

b. The one-pen servo recorder shown in Figure 1-1 is identified as Model MS411B (Stock No. S-22905), and is primarily used to continuously (normal operation) or alternately (Time Share) record AC watts or vars in one- or three-phase circuits.

c. Two versions of a three-pen servo recorder are also available to measure and record a wider range of AC power parameters. The Model MS413B (Stock No. S-22903) has the capacity to simultaneously record watts, vars, and watt demand or var demand in one- or three-phase circuits. KW/hours or kVar/hours (as required) are displayed by a front-panel digital counter on the Demand Integrator Module. A three-position switch is also provided on the front panel so that the operator may select a 15, 30, or 60 minute demand time interval.

d. The three-pen recorder identified as Model MS413B (Stock No. S-22904) will simultaneously record: watts, vars, power factor, volt-amperes, or VA demand, in any combination of three. Watt demand or var demand may be substituted for any one of the three AC power parameters being recorded. KW/hours or kVar/-hours (as required) are also displayed on the Demand Integrator Module of this recorder. In addition, either kVA or power factor can be read out on a liquid crystal display (LCD) on the front panel of the Power Factor/ KVA Module.

e. All three models of Power Survey Demand Recorders are equipped with rear panel connections to the servo amplifier of the recorder for 0-1mA DC and 0-1V DC inputs. These features permit the use of various external transducers for recording other parameters such as frequency, temperature, or pressure. On three-pen units, additional 0-1V DC or 0-1mA DC inputs are provided for external signal applications to the Demand Integrator Module. This module also has connection provisions for remote reset switching.

f. All AC current-related parameters are measured through the use of external clamp-on transformers. These hand-held units are supplied so that the operator can connect to live circuits easily without breaking load-line conductors. Each current transformer is designed with insulated handle grips, pivotal frame jaws, a 10-foot cable, and is rated for indoor use on AC circuits up to 600 volts and up to 1000 amps. Separate 10-foot potential input leads for voltage-related measurements are also supplied.

g. In the three-pen recorder, different color inks are used to distinguish between the overlapping channel traces; red is used for Channel A, black for Channel B, and blue for Channel C. Fluorescent red, black, and blue pen targets (pointers) are also painted on the front side of the ink cartridges to identify cartridge/channel colors and to visually indicate the respective channel's measurement value on the segmented scaleplate. The channel input terminal block is color-coded to match the red, black and blue channels.

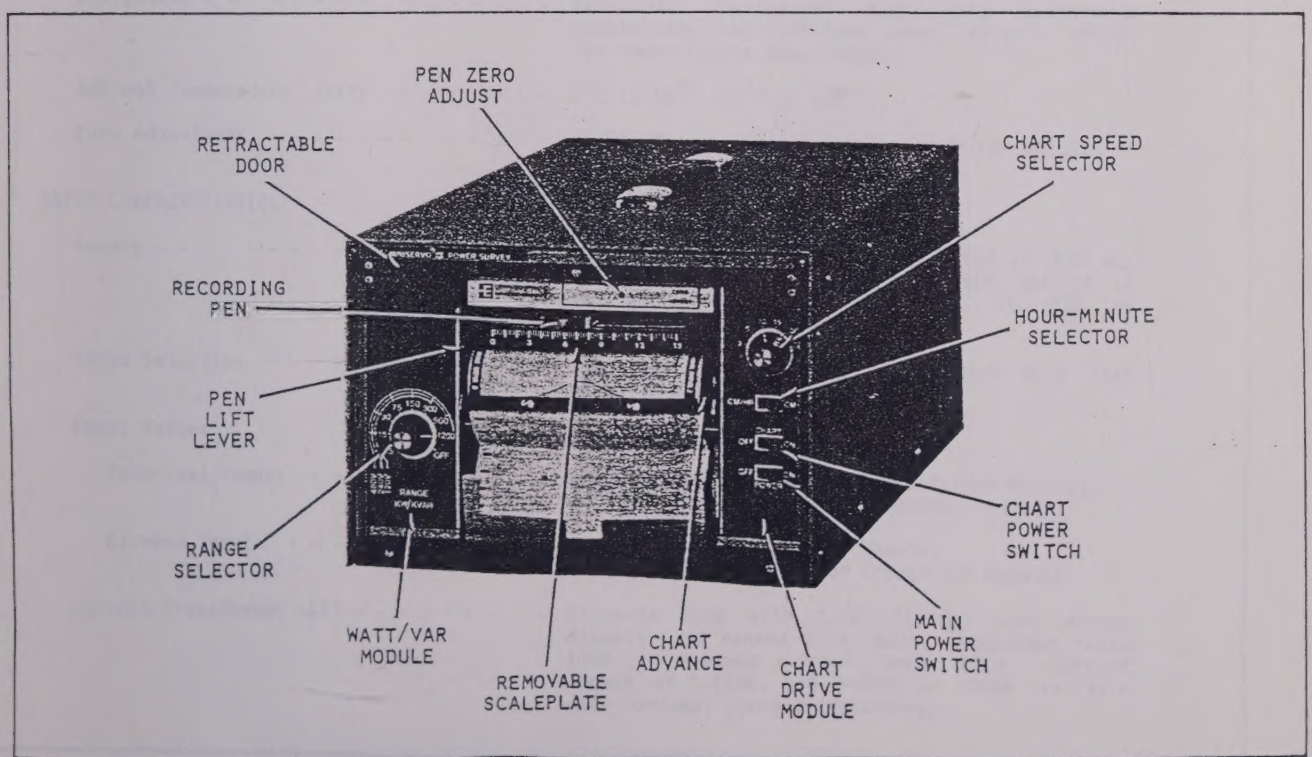


Figure 1-1. Single-Pen Power Recorder - Stock No. S-22905.

h. A nine-position RANGE KW/KVAR selector switch is provided on the Watt/Var Module front panel of each recorder. Full scale ranges of from 7.5 to 1200 KW and KVAR, at potential ranges up to 600V AC may be recorded. In addition, the OFF/ZERO ✓ position allows a check of the zero pen position. The recorder chart drive is a twelve-speed system that permits the operator to select feed rates of from 2 to 60 cm/hr or cm/min by positioning front-panel switches. The recording strip chart is a Z-fold type with a full 10-cm span; the chart pack is easily loaded into a slide-out tray at the front of the recorder.

1.2 SPECIFICATIONS

All electrical and mechanical characteristics of the MS411B (#S-22905), MS413B (#S-22903) and (#S-22904) Power Survey Demand Recorders are listed in Table 1-1. For calibration specifications, see Servicing Documentation.

Table 1-1. Technical Specifications.

INSTRUMENT TYPE:	
MS411B (Stock #S-22905)	Single-channel Watt/Var, strip-chart, servo recorder with 3 clamp-on current transformers and leads supplied.
MS413B (Stock #S-22903)	Three-channel Watt/Var, Demand Integrator, strip-chart, servo recorder with 3 clamp-on current transformers and leads supplied.
MS413B (Stock #S-22904)	Three-channel Watt/Var, Demand Integrator, Power Factor/kVA, strip-chart, servo recorder with 3 clamp-on current transformers and leads supplied.
RECORDING SYSTEM:	
Method of Writing	Disposable ink cartridge with integral marking tip and ink supply (per channel).
Step Response Time	0.5 seconds full-scale.
Chart Paper	Z-fold, rectilinear with 10cm active span; 20m long with 5cm folds.
Scaleplate	Removable transparent type with multirange annotations and left-hand zero. Zero is offset for Power Factor measurements.
Ambient Temperature Limits	$0^{o}C$ to $50^{o}C$ ($32^{o}F$ to $122^{o}F$).
Zero Adjustment	±100% of span. Front-panel screwdriver adjust.
INPUT CHARACTERISTICS:	
Ranges	0-7.5, 15, 30, 75, 150 or 300 KW/KVAR at 120V AC. 0-7.5, 15, 30, 75, 150, 300 or 600 KW/KVAR at 240V AC. 0-7.5, 15, 30, 75, 150, 300, 600, or 1200 KW/KVAR at 480V AC.
Range Selection	9-position rotary front-panel switch with last position OFF/ZERO ✓.
Input Values:	
Potential Inputs	0-600V AC (@line frequency to Watt/Var Module). 0-1V DC (to Servo Amp or Integrator Module).
Current Inputs	0-1A (from CT to Watt/Var Module). 0-1mA DC (to Servo Amp or Integrator Module).
Current Transformer (CT)	Clamp-on type with 2.12" (5.4cm) core window diameter and banana plug leads. Step-down ratio 1000:1. Maximum current input 1000A. Current inputs of 0-150A, and 0-2000 or 3000A available with optional current transformers.

Continued--

Table 1-1. Technical Specifications (Continued).

OUTPUT CHARACTERISTICS:

Analog Recordings - - - - - - - - - - - -

PARAMETER	RECORDER STOCK NO. S-22905	S-22903	S-22904
kWatts	•	•	•
kVars	•	•	•
kW Demand		•	•
kVar Demand		•	•
kVA			•
kVA Demand			•
PF			•

Analog Record Accuracy - - -

RANGE kW/kVAR	SYSTEM ACCURACY (±%)* kW	kVAR	kVA	kW DEM.	kVAR DEM.	kVA DEM.	PF
1200	2.1	2.1	2.9	2.6	2.6	2.9	2.9
600	2.1	2.1	2.9	2.6	2.6	2.9	2.9
300	2.1	2.2	2.9	2.6	2.7	2.9	2.9
150	2.2	2.3	3.0	2.7	2.8	3.0	3.0
75	2.3	2.4	3.2	2.8	2.9	3.2	3.2
30	2.5	2.9	3.7	3.0	3.4	3.7	3.7
15	2.9	3.7	4.1	3.4	4.2	4.1	4.1
7.5	3.7	5.3	6.5	4.2	5.8	6.5	6.5

*Figures include ±0.5% servo system accuracy and ±1.0% current transformer accuracy.

Displays:

KW/kVAR-HRS. Counter - - - - - - - - - - 6-digit electromechanical counter that displays kW-hrs or kVar-hrs, depending on input to Demand Integrator Module from Watt/Var Module. Displays up to 99999.9 kW-hrs or kVar-hrs. Manual push button reset.

Power Factor/kVA Display - - - - - - - 3 1/2 digit liquid crystal display (LCD) showing power factor or kVA depending on position of front panel switch. Negative (-) sign denotes leading PF.

Display Accuracy - - - - -

PARAMETER	ACCURACY (±%)* FOR kW/kVAR RANGES 1200	600	300	150	75	30	15	7.5
kW-hrs.	1.6	1.6	1.6	1.7	1.8	2.0	2.4	3.2
kVar-hrs	1.6	1.6	1.7	1.8	1.9	2.4	3.2	4.8
KVA	2.4	2.4	2.4	2.5	2.7	3.2	3.6	6.0
PF	2.4	2.4	2.4	2.5	2.7	3.2	3.6	6.0

*Figures include ±1.0% current transformer accuracy.

INTEGRATOR MODULE:

Demand Time - - - - - - - - - - - - - - - 15, 30 or 60 min. selectable by front-panel switch. Accuracy based on line frequency.

Demand Reset - - - - - - - - - - - - - - - Actuated by front-panel push button, remote contact closure, or changing Demand Time switch. Remote: Open V< 6V DC; Closed V< .2V DC, I< .1mA, R< 10Ω. 5 min. maximum closure time.

CHART DRIVE SYSTEM:

Chart Feed Rates - - - - - - - - - - - - - 2, 5, 10, 15, 30 and 60 cm/hr or cm/min.

Drive Controls - - - - - - - - - - - - - - 6-position rotary rate selector switch, CM/HR-CM/MIN switch, and CHART OFF/ON switch; all on Chart Drive Module front panel.

Continued--

Table 1-1. Technical Specifications (Continued).

POWER REQUIREMENTS:	
AC Line Source	115 or 230 volts (±10%), rear panel switch selectable. Fuse provided. Specify 50 or 60Hz.
INSTRUMENT CASE:	
Style and Features	NEMA II drip-proof bench-type, with carrying handles, foot rests, removable rear safety cover and self-storing Lexan® front door. Three-pen model also has tilt bail.
Overall Size	See dimensional diagrams in Figure 2-1.
Approximate Weight	S-22905 - 16 1/2 lbs. (7.5 Kg). S-22903 - 26 1/2 lbs. (12 Kg). S-22904 - 28 lbs. (12.7 Kg).

1.3 PRINCIPLES OF OPERATION

a. The overall measuring and recording system employed in Miniservo® III Power Survey Demand Recorders is illustrated in the simplified block diagram of Figure 1-3. Each recorder includes a number of electronic signal-conditioning modules with input and output interconnections made accessible to the operator on a rear panel. All instruments contain a three-element watt/var transducer with range selection circuitry, an electronic chart drive control module, a DC stepper-drive motor and mechanical chart transport. The single-pen recorder (Stock No. S-22905) also includes a Watt/Var Time Share circuit and one servo recording system. Both three-pen recorders (Stock No. S-22903 and S-22904) feature a Demand Integrator Module and three separate servo recording systems. A Power Factor/KVA Module is also incorporated into the S-22904 recorder. This permits additional direct measurements of power factor, kVA, and kVA Demand.

b. All input signals to the recorder enter through a connection panel at the rear of the instrument. AC current inputs are supplied from clamp-on transformers attached to the desired conductors in the power circuit to be measured. These input signals are supplied via 10-foot cables. Each is terminated in color-coded banana plugs at the transformer end, and a polarized 'Jones'-type socket at the recorder end. AC potential input leads terminate in crocodile clips at the AC source, and in spade lugs at the recorder. These leads are color-coded to match colored terminal blocks on the recorder rear panel.

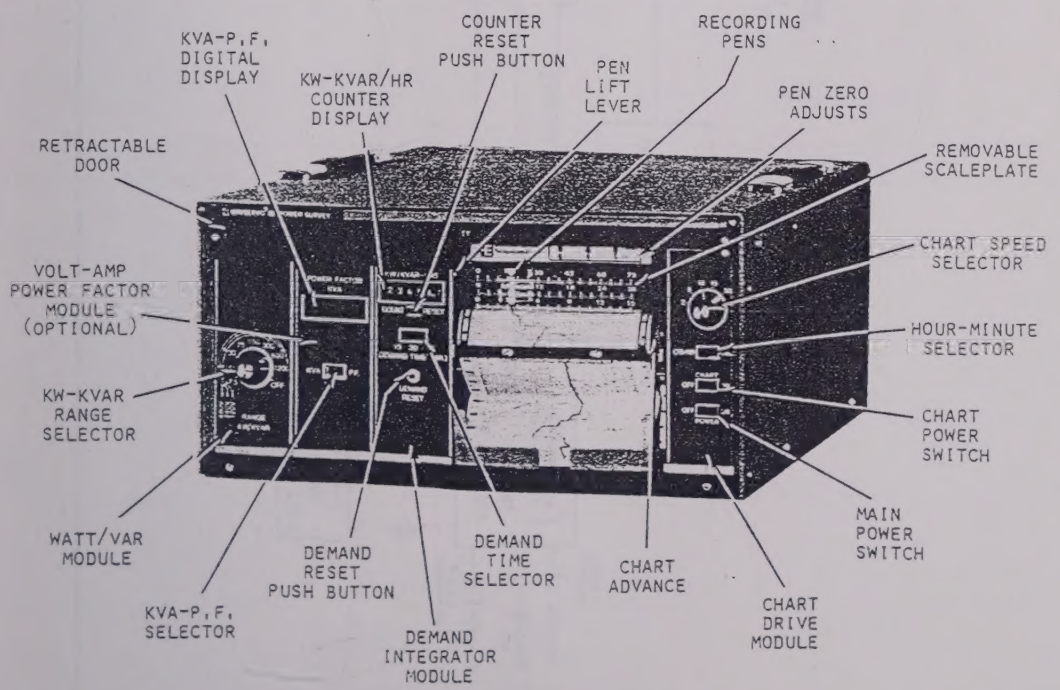


Figure 1-2. Three-Pen Power Recorders - Stock Nos. S-22903 and S-22904.

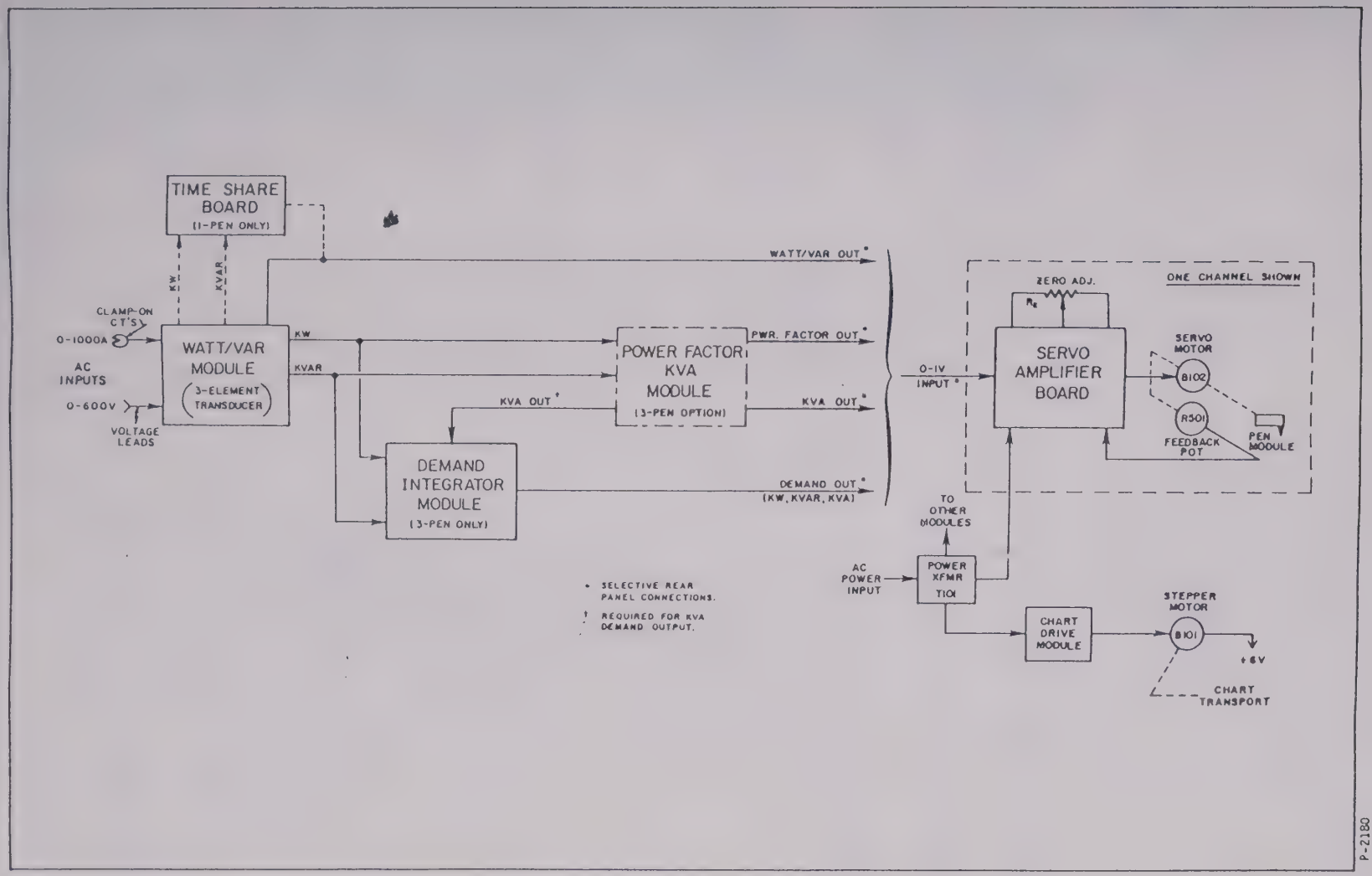


Figure 1-3. Overall Block Diagram of AC Power Measuring and Recording System.

c. External power signals are applied to the input circuits of the Watt/Var Module. Output signals from this module (or other modules, if supplied) are fed to the Servo Amplifier Board. This measuring and recording system operates on a null-balance servo principle.

d. In the basic servo loop, the unknown input voltage to the servo amplifier is compared with an internal feedback voltage representing pen position. The difference or error signal thus developed is amplified and used to drive the servo motor in a direction that causes the system to balance. The pen accurately records this movement over a calibrated chart span of 10 cm (3.94 in). The complete servo loop and function modules for one recording channel is shown in Figure 1-3.

e. Terminals are also provided on the rear panel for 0-1V DC or 0-1mA DC external signal inputs. These signals can be processed either of two ways. First, the signals can be connected directly to the servo amplifier input of a selected channel and traced on the chart paper. Second, by using connections outlined in Figure 3-2D, the external signals are fed through the Demand Integrator Module (if supplied). The integrated signal is recorded on the chart paper, and a count totalization appears on a front-panel electromechanical counter.

f. The various AC parameters that can be recorded and/or displayed are listed in Table 1-1. These outputs are obtained by specific recorder and module interconnections, as shown in Figures 3-1, 3-2, and 3-6. For more detailed principles of operation on each module and standard recorder feature, as well as complete wiring diagrams and schematics, refer to separate Servicing Documentation.

2. INSTALLATION

2.1 UNPACKING INSTRUCTIONS

a. Examine packing case for damage prior to opening. If the packing case shows damage, make a notation to that effect on the express receipt or freight bill. If the shipment within is damaged, notify the carrier and your Esterline Angus representative immediately. The following standard items have been inspected and carefully packed in the Miniservo shipping carton.

ITEM	QUANTITY
Recording Instrument	1
Clamp-on Transformer	3
Current Input Cable	3
Potential Input Lead	4
Ink Cartridge	A/R
Instruction Manual	1
Recording Chart	A/R
Fuse Kit	1

b. Remove the packing material from the carton carefully and check off all items listed on the packing slip as they are unpacked. Inspect all contents for damage.

CAUTION: Do not attempt to operate a damaged instrument or clamp-on transformer.

c. Each instrument is carefully inspected and properly calibrated at the factory prior to shipping, and should be ready for operation as soon as it is unpacked and set up.

d. Setting up the instrument for operation basically consists of the following procedures:

(1) Note mounting considerations.

(2) Select operating power.

(3) Install chart paper.

(4) Install pen module(s).

(5) Connect analog input signals.

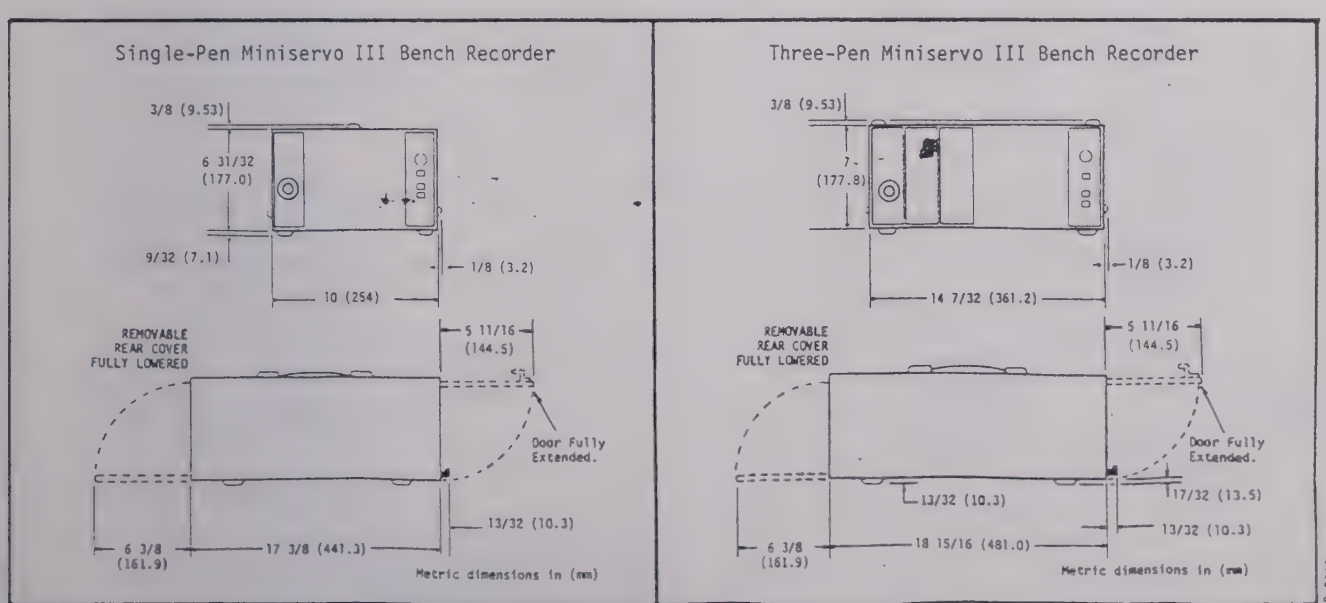


Figure 2-1. Dimensional Diagrams for Power Recorders with NEMA II Case Designs.

2.2 INSTRUMENT MOUNTING

a. This recording instrument has been designed primarily for portable and bench-top applications and, therefore, no special installation procedures are required. Case dimensions are shown in Figure 2.1.

b. Foot rests are attached to the bottom of the instrument to protect supporting surfaces. The three-pen model has a tilt bail located under the case to improve front-panel viewing.. The single-pen unit may also be tilted backward a maximum of 20 degrees without hindering the automatic refolding of used chart.

c. Preferably, the recorder should be positioned in a clean well-lighted location that affords convenient access for the operator. It should not be subjected to excessive vibration or extreme temperature and/or humidity conditions. If excessive dust, moisture or corrosive fumes are present, a properly vented and filtered enclosure should be used to protect the instrument.

2.3 OPERATING POWER

CAUTION: Do not apply power to recorder until unit is set up for desired AC source operation.

a. Each recorder is equipped with a Power Mode switch and fuse kit to allow either 115V or 230V AC operation. Before placing the instrument into operation, check to ensure that the proper fuse has been installed and the Power Mode switch is set for proper line voltage. When a stock instrument leaves the factory it is normally set up for 115V operation.

NOTE: Chart drive must be operated at correct frequency. Refer to rear panel label for either 50 or 60Hz specification.

b. The Miniservo recorder may be set to operate on either 115 or 230V by the following steps:

(1) Gain access to rear panel by turning the retaining screw(s) located along the top of the rear panel cover three-quarters of a turn counterclockwise, then remove cover. Set Power Mode switch, located on the rear panel, to desired power line voltage (either 115V or 230V AC). Refer to Figure 2-4, 2-5 or 2-6 for switch location.

(2) Remove fuse retainer cap from rear-panel holder by turning cap in direction of arrow.

NOTE: Spare fuses are provided; a 1/2 amp for 115V operation, and a 1/4 amp for 230V operation.

(3) Select proper fuse and place into fuse holder. Replace cap by turning in opposite direction of arrow. The recorder is now ready to receive AC power at the frequency (50 or 60Hz) specified.

2.4 CHART INSTALLATION

Only Esterline Angus precision charts should be used in this instrument for guaranteed accuracy and optimum performance. To ensure continuous records, inspect the recorder periodically for its remaining chart supply. Always keep enough charts on hand to operate the recorder for at least one month. Charts must be ordered by assigned numbers, which are printed along the right-hand margin of each chart.

2.4.1 CHARTING PROCEDURE

To install chart paper in the recorder, refer to the chart threading illustration in Figure 2-2 and proceed with the following steps:

(1) Open front door and slide into top of recorder case. Place main POWER switch in its OFF (left-hand) position. Grasp lower edge of scaleplate and swing plate outward and upward to remove it from top retaining clips.

(2) Raise pen holder(s) using Pen Lift lever. Grasp front of chart tray at bottom of recorder and slide tray fully outward until it stops.

(3) Remove Z-fold chart from its container. To help paper feed more freely, grasp chart pack and fan one end of sheets; then repeat at opposite end.

(4) Orient pack so that edge with elongated holes is on left-hand side and printed side of paper will face recorder as chart unfolds from top of pack. Bend pack at angle and insert it into rear supply compartment through opening on right side of tray.

(5) Lift out a few folds of chart from top of supply pack and insert leading edge of paper back between Mylar threading chute and drive roll.

(6) Rotate Chart Advance Thumbwheel downward and thread chart over top of drive roll. See that drive roll pins engage chart holes at both sides. Guide leading edge of chart behind folding wedge located in front of drive roll.

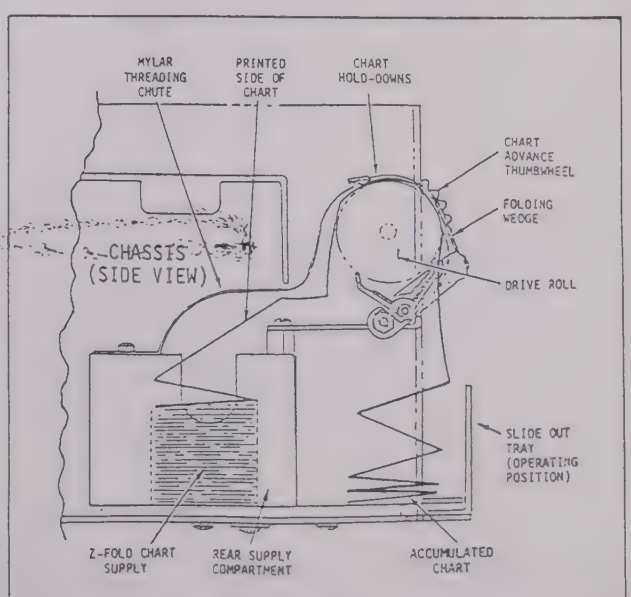


Figure 2-2. Chart Threading Diagram with Tray Closed.

(7) Slide chart tray back into recorder. Continue to rotate thumbwheel until several paper folds enter front accumulator compartment of tray (Figure 2-2).

NOTE: If chart does not start to fold properly, manually position first few folds into tray.

(8) Replace scaleplate by first inserting top edge into retaining clips; and then swing plate down until it snaps firmly into position. To check operation, turn on main POWER switch, select chart speed, and place CHART switch in its ON position.

NOTE: A 1/8" wide blue line that starts approximately one meter (39") from end of chart in left-hand margin, will indicate end of chart is near.

2.5 INK CARTRIDGE INSTALLATION

a. Disposable pen-and-ink cartridges are employed in the writing system of Miniservo III recorders. These plug-in modules are supplied as accessories in the instrument service kit. Single-pen recorders are supplied with red ink cartridges and a snap-on scale pointer; while the three-pen model uses cartridges of different ink colors and pen tip length for each recording channel. Standard ink colors are: Red for channel "A", black for channel "B", and blue for channel "C". Refer to Figure 2-3 for the correct operating position of each channel cartridge.

b. To ensure continuous records, check supply of ink cartridges when changing charts. Each cartridge holds enough ink for approximately 3600 feet of chart trace. Always keep a supply of cartridges on hand to operate the recorder for at least one month. Replacement cartridges are available in convenient six-packs.

2.5.1 INKING PROCEDURE

To install an ink cartridge, proceed with the following steps:

(1) Remove ink cartridge from accessory package supplied. On single-pen units, slide scaleplate pointer onto cartridge pen staff until it snaps over top of cartridge.

(2) Grasp lower edge of scaleplate and swing plate outward and upward to remove from top retaining clips. Move Pen Lift lever to raise cartridge holder.

(3) Remove the protective cap from pen tip and, with pen tip facing down, insert module straight back into cartridge holder.

NOTE: On three-pen models (Fig. 2-3) install cartridges with shortest pen tips first. A piece of paper or blotter may be inserted under pen tips to avoid ink traces on chart.

(4) Move Pen Lift lever to lower pen or pens onto chart. Replace scaleplate by inserting top edge in first, then swing plate downward until it snaps into position. With chart installed, select a chart speed, turn on POWER and CHART switches, and check operation.

NOTE: Retain protective cap to replace on pen tip when recorder is to be inoperative for long periods.

2.6 POWER AND GROUND WIRING

a. Power to operate the bench-styled recorder is conducted through a permanently-attached line cord that extends approximately seven feet from the rear of the case. The cord is terminated in a 3-prong plug for connection to a properly earth-grounded, 3-wire AC receptacle.

WARNING: For safe operation, recorder MUST be properly connected to earth ground as directed in the following paragraph.

b. An individual ground connection point is provided on the rear panel of the recorder. To gain access to the panel, turn the retaining screw(s) located along the top of the rear panel cover three-quarters of a turn counterclockwise, then remove cover. This screw terminal is located on a green terminal block as shown in Figure 2-4, 2-5, or 2-6. As a safety precaution, a #12 wire is to be used to connect this terminal to an external earth- or building-ground point.

2.7 SIGNAL CONNECTIONS

All input signal wiring to the recorder is made at a connection panel on the rear of the instrument case. To gain access to the panel, turn the retaining screw(s) located along the top of the rear panel cover three-quarters of a turn counterclockwise, then remove cover. Before attempting to make any signal connections, be sure that the recorder is properly grounded and refer to Figure 2-4, 2-5, or 2-6 for specific wiring points. See paragraph 3.6 for details.

WARNING: To prevent shock hazard, secure rear cover before connecting current transformer or potential input leads to AC sources.

3. OPERATION

3.1 GENERAL

This section of the manual includes operating instructions for three different models of Power Survey Demand Recorders. No attempt should be made to operate an instrument until all installation and operating instructions have been thoroughly studied. Normal care when handling any precision piece of equipment should be exercised by the user.

NOTE: See Manual Appendix for optional attachments.

3.2 RECORDING CONTROLS

Basic recorder controls for each model are essentially the same unless otherwise stated. The following paragraphs describe control functions associated with the Chart Drive Module, chart transport, and instrument rear panel. Refer to Figure 1-1 or 1-2 for location of front panel controls.

(Continued on page 11)

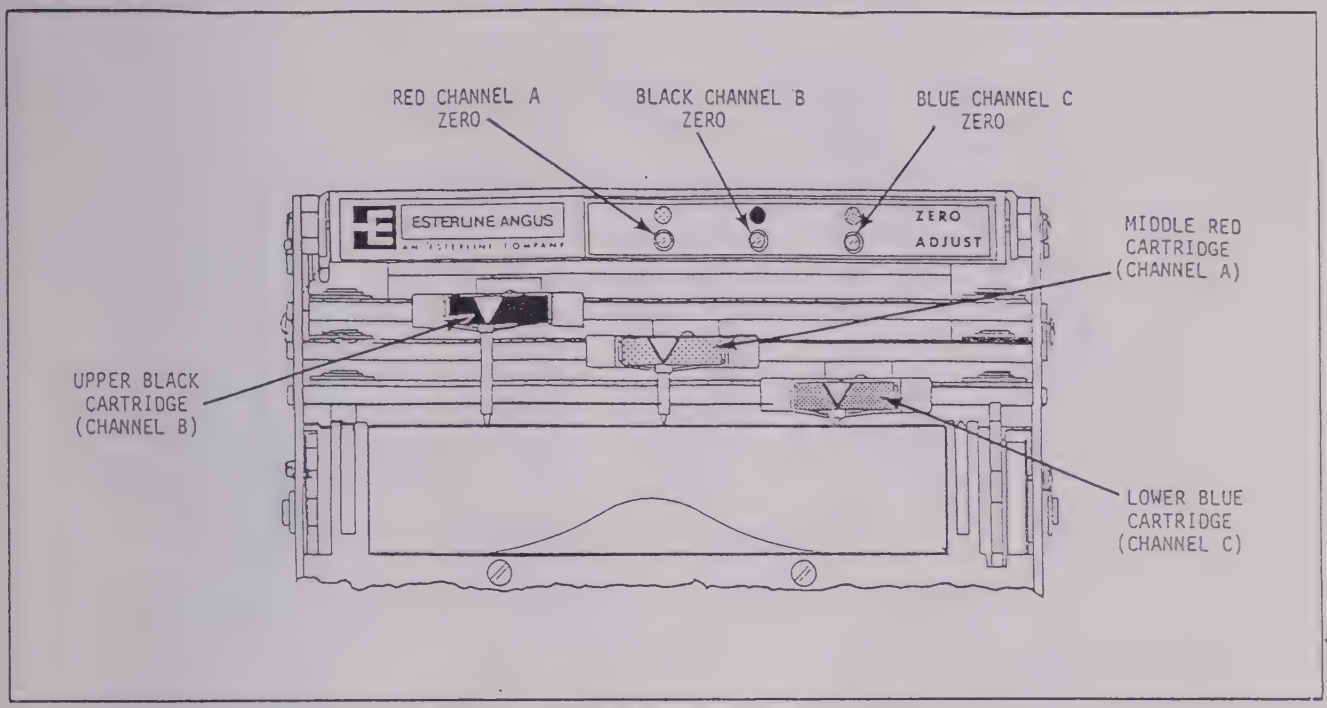


Figure 2-3. Ink Cartridge and Zero Adjust Locations for Three-Pen Recorder.

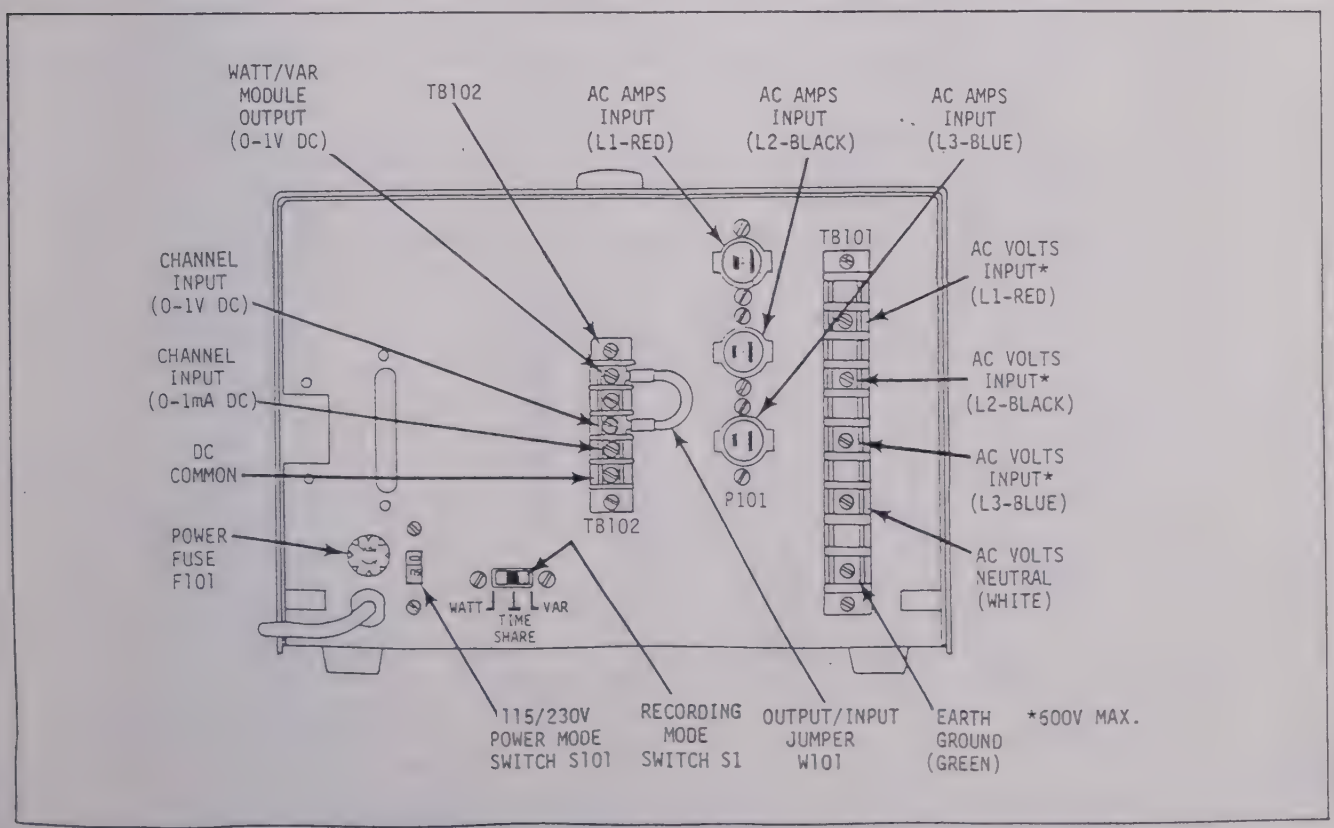


Figure 2-4. Connection Panel of Single-Pen Recorder (S-22905) with Rear Cover Removed.

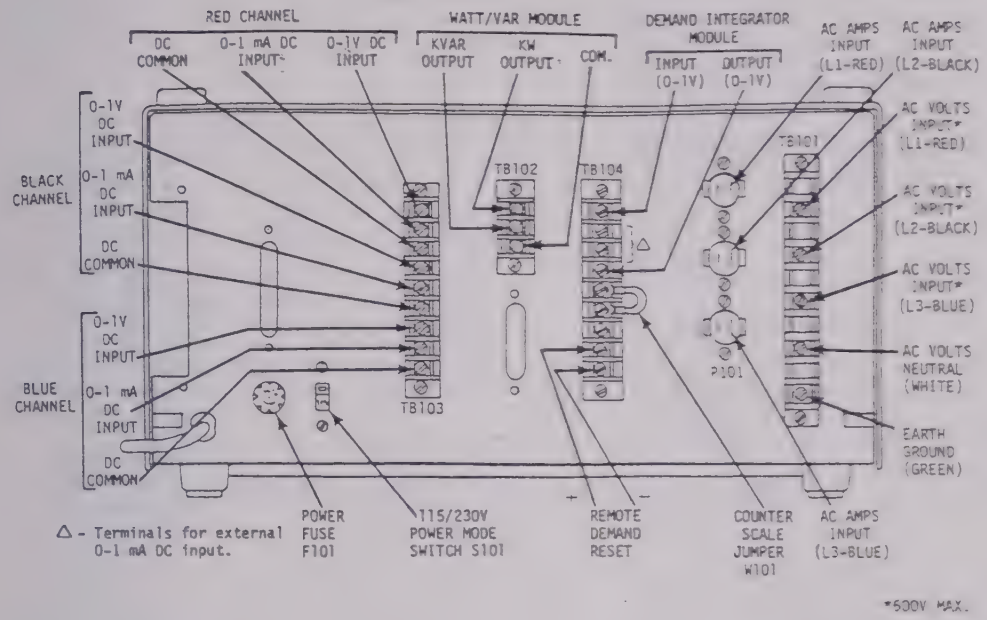


Figure 2-5. Connection Panel of Three-Pen Recorder (S-22903) with Rear Cover Removed.

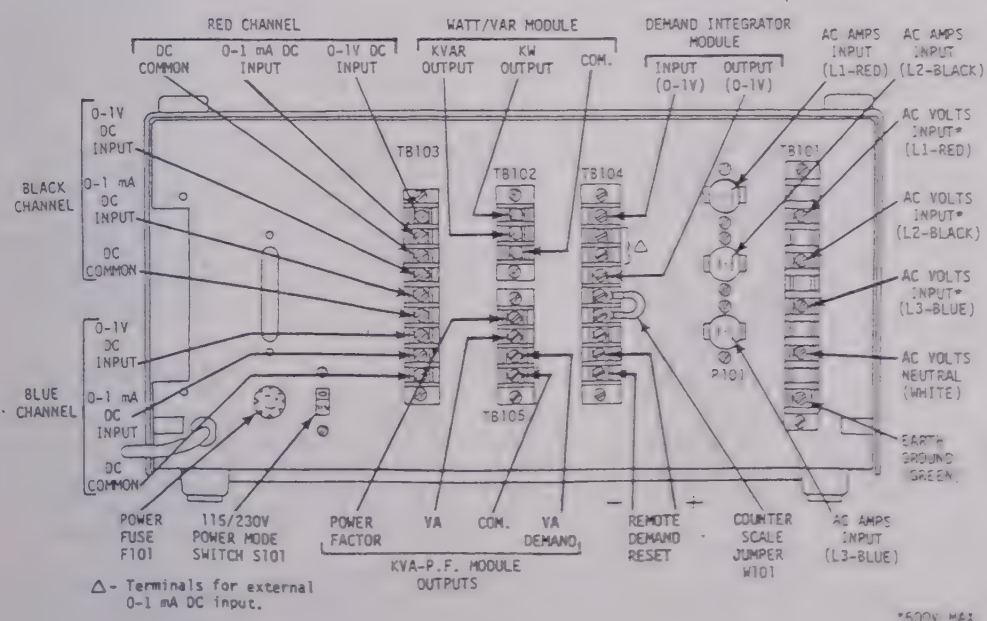


Figure 2-6. Connection Panel of Three-Pen Recorder (S22904) with Rear Cover Removed.

3.2.1 FRONT PANEL CONTROLS

a. Pen Lift (Lever): The small metal arm located on the left end of the scaleplate is a pen lift lever. This device permits the operator to raise or lower the recording pen or pens as desired. To raise the pen(s) from the chart, move the lever arm upward (single-pen) or downward (3-pen). The pen(s) can be lowered to recording position by moving the lever downward (single-pen) or upward (3-pen).

b. Chart Advance (Thumbwheel): This mechanical adjustment is provided so that the operator can advance the chart paper manually. Rotating the wheel downward overrides the internal drive system and propels the chart forward. This control should always be used when charting the instrument.

c. POWER OFF/ON Switch: This is a two-position slide switch on the Chart Drive Module. It is used to control power to all electronic modules and the chart drive. To energize the recorder, move the switch to its ON position. Always place the switch in its OFF position when recorder is not in use, or when charting, inking or servicing the unit.

d. Chart Speed Selector Switch: This six-position rotary switch offers the operator a selection of six different centimeter feed rates for both minute and hour chart speeds. It may be rotated in either direction with power off or with the chart in motion.

e. CM/HR-CM/MIN Switch: A two-position slide-type switch that is used to select either hour speeds or minute speeds for any feed rate setting. The switch may be operated while the chart is in motion.

NOTE: When interpreting chart traces on 3-pen units, bear in mind that red pen records 5mm behind black pen, and blue pen records 5mm behind red pen.

f. CHART OFF/ON Switch: This two-position slide-type switch controls power to the chart drive PC board when the main POWER switch is ON. Place this switch in its ON position to start chart motion, and in its OFF position to stop chart. This switch may be used to conserve chart paper when a timed record is not required.

g. ZERO ADJUST: One screwdriver adjustment potentiometer is provided for each recording channel. Located directly above the scaleplate, the pot is used to zero the recording pen on the chart or to suppress or elevate electrical zero to a desired offset value. Refer to Figure 1-1 for location of zero adjust on one-pen model, and Figure 1-2 or Figure 2-3 for zero adjusts on three-pen models.

3.2.2 REAR PANEL CONTROLS

a. The location of each rear-panel feature is shown in Figure 2-4, 2-5 or 2-6--depending upon the model supplied. In addition to the following switches, each connection panel includes a power line fuse, terminal blocks for AC voltage and optional DC inputs, as well as plug connectors for current transformer inputs.

b. Power Mode Switch: A two-position slide switch that permits the operator to select either 115V or 230V AC recorder operation.

CAUTION: Power source must match this switch setting. Also check recorder fuse rating.

c. Recording Mode Switch: This is a three-position slide switch supplied on all single-pen recorders (see Figure 2-4). It offers the operator three different recording modes. In its WATT position, the pen will continuously record measured watts; in the VAR position, the pen will continually record measured vars; and in its center TIME SHARE position, the pen records watts and vars alternately. Recording intervals for the time-share mode of operation are 10 minutes of watts and 5 minutes of vars at a power frequency of 60 Hz. At 50Hz, the intervals are extended to 12 minutes and 6 minutes (watts and vars) respectively.

WARNING: Exercise extreme caution when changing settings on this switch with high-voltage connected to rear panel.

3.3 WATT/VAR MODULE CONTROLS

NOTE: See Figure 1-1 or 1-2 for control locations.

a. RANGE KW/KVAR Selector Switch: A nine-position rotary switch used to select ranges of from 0-7.5, 15, 30, 75, 150, or 300 KW or KVARS at 120V AC; 0-7.5, 15, 30, 75, 150, 300, or 600 KW or KVARS at 240V AC; or 0-7.5, 15, 30, 75, 150, 300, 600, or 1200 KW or KVARS at 480 or 600V AC. The OFF/ZERO ✓ position allows a check of zero pen position.

b. Calibration Controls: All internal calibration controls for this module are precisely adjusted at the factory, and should not be disturbed. If recalibration is required, refer to Servicing Documentation.

3.4 DEMAND INTEGRATOR MODULE CONTROLS

NOTE: See Figure 1-2 for locations.

a. COUNT RESET Switch: A manually-operated, front-panel push button switch used to reset the electromechanical KW/KVAR-HRS. counter.

b. DEMAND TIME (MIN) Switch: A three-position switch for selecting the desired count integration time interval. 15, 30, or 60 minutes per integration may be chosen.

c. DEMAND RESET Switch: A momentary-contact, front-panel push button that is used to reset module output; it also stops integration of the electromechanical counter, while held in.

d. Remote Demand RESET: Two terminals are provided on the recorder rear panel for module output reset by external contact closure. Many devices can be used to activate reset such as switches, relay contacts, TTL, DTL, CMOS, MOS, optical isolators, etc. Refer to specifications in Table 1-1.

e. Calibration Controls: All internal calibration controls for this module are precisely adjusted at the factory. If module recalibration is required, refer to Servicing Documentation.

3.5 POWER FACTOR/KVA MODULE CONTROLS

NOTE: See Figure 1-2 for control locations.

a. KVA/P.F. Switch: A two-position switch used to select desired AC power parameter (kVA or power factor) to be shown on front panel liquid crystal display (LCD).

b. Front Panel LCD Display: A 3 1/2 digit readout which will display KVA or power factor, as selected by two-position front panel switch. A negative sign preceding the digits indicates leading power factor.

c. Calibration Controls: All internal calibration controls for this module are precisely set at the factory. If module recalibration is required, refer to Servicing Documentation.

3.6 REAR PANEL CONNECTIONS

a. Prior to attaching the instrument's power cord to an AC receptacle or connecting to any signal sources, the current input and potential input leads supplied must be properly connected to the recorder. In three-pen recorders, jumper wiring must also be completed between module terminals for various recording functions.

b. Gain access to the connection panel by turning the retaining screw(s) located along the top of the rear panel cover three-quarters of a turn counterclockwise, then remove cover. Refer to the correct illustration in Figure 2-4, 2-5 or 2-6 for specific wiring points of the recorder supplied. A #12 wire must be connected to earth ground from the green color-coded terminal labeled GROUND on the recorder.

3.6.1 CURRENT INPUT LEADS

(1) Observing color codes on cable leads supplied, attach 2-pin polarized connector on end of each cable to each current transformer input (P101) on rear panel of recorder--one each for red, black, and blue color-labeled plugs.

(2) Connect banana plugs on other end of leads to each clamp-on current transformer supplied. DO NOT connect transformers to any source at this time. The color-coded plugs at the transformer may have to be reversed when external connections are made so that the white banana plug is always toward the load side of the measured power line.

WARNING: Although current transformer has internal protection, a maximum open-circuit potential of up to 60V AC may be present with unit attached to current-carrying conductor.

3.6.2 POTENTIAL INPUT LEADS

AC potential input leads are connected to screw terminals on terminal block TB101 with spade lug terminations. TB101 is located on the recorder rear panel and is labeled VOLTAGE INPUTS. One set of four color-coded conductors is supplied with each recorder. The terminal block is also color-coded to aid in lead connection.

WARNING: DO NOT connect other ends of leads to any voltage source at this time.

3.6.3 MODULE INTERCONNECTIONS

Electrical interconnections between the recorder and recorder modules are accomplished, for the most part, with jumper wires between terminal blocks on the rear panel. On three-pen recorders, refer to Figure 3-1 for standard wiring diagrams and to Figure 3-2 for alternate wiring connections. Always replace rear cover before making connections to external AC signal sources.

3.7 OPERATING PROCEDURES

3.7.1 GENERAL

The following basic operational steps for one- and three-pen recorders assume that initial installation procedures have been completed, chart paper is installed, and that the inking system for each recording channel is ready for use.

(1) Connect recorder power cord to receptacle. Place POWER switch in ON position and allow recorder to warm up at least 5 minutes to obtain specified accuracy.

(2) With chart running, place Range Selector Switch on Watt/Var Module in OFF/ZERO ✓ position and observe pen position on chart. Pen should come to rest on zero reference line of chart. If it does not, adjust ZERO pot located on bracket above scaleplate. Repeat procedure for each channel of three-pen recorder.

NOTE: See Step 3 under paragraph 3.7.3.

(3) Set Range Selector Switch to desired position (7.5-1200 KW/KVAR). If measurement is unknown, preset to highest range and then reduce setting until suitable measurement is obtained. Generally, higher resolution measurements will be obtained in the upper two-thirds of the chart span.

CAUTION: DO NOT exceed maximum values specified in table of Figure 3-3.

(4) Observing color coding, attach clamp-on transformers to current conductors being measured (see Fig. 3-3). Make sure that white banana plug on transformer is toward load. Secondary of transformer has 0-1A output. Jaws must be completely closed for accurate current measurement.

WARNING: Always follow standard electrical safety procedures when connecting to high-voltage lines.

(5) Observing color coding, attach insulated crocodile clips on supplied potential input leads to AC voltage points of external source (see Fig. 3-3). If spade lug connections are desired, slide boot insulators upward on leads, loosen screws and remove clips.

NOTE: Optional CTs are available. One is larger than the standard unit, and extends current inputs up to either 0-2000 or 3000A. The other unit is smaller, and is especially useful in confined areas. It is rated for inputs up to 150A.

3.7.2 ONE-PEN RECORDER OPERATION

(1) Follow steps (1) through (5) in paragraph 3.7.1.

(2) To record watts or vars continuously, simply place Recording Mode Switch, located in lower left hand corner of rear panel (Figure 2-4), in either the WATT or VAR position. To alternately record watts and vars, place switch in the TIME SHARE position. With

60 Hz recorder power input, watts will be recorded for 10 minutes, then vars for 5 minutes; and then the cycle repeats itself.

NOTE: Time share interval for 50 Hz power input is 12 minutes and 6 minutes for watts and vars, respectively.

3.7.3 THREE-PEN RECORDER OPERATION

(1) Follow steps (1) through (5) in paragraph 3.7.1.

(2) Refer to Figure 3-1 or 3-2 for rear panel wiring diagrams. Select AC power parameters desired for recording, and make jumper connections. KW- or kVar-hrs. are displayed on panel counter, but cannot be recorded.

(3) If power factor is to be recorded, set RANGE switch to OFF/ZERO ✓ position and adjust ZERO until pen is elevated to unity point on P.F. scaleplate (33.3% of span). Set RANGE switch to desired position.

NOTE: Short 1V and COM terminals to adjust zero in early production models.

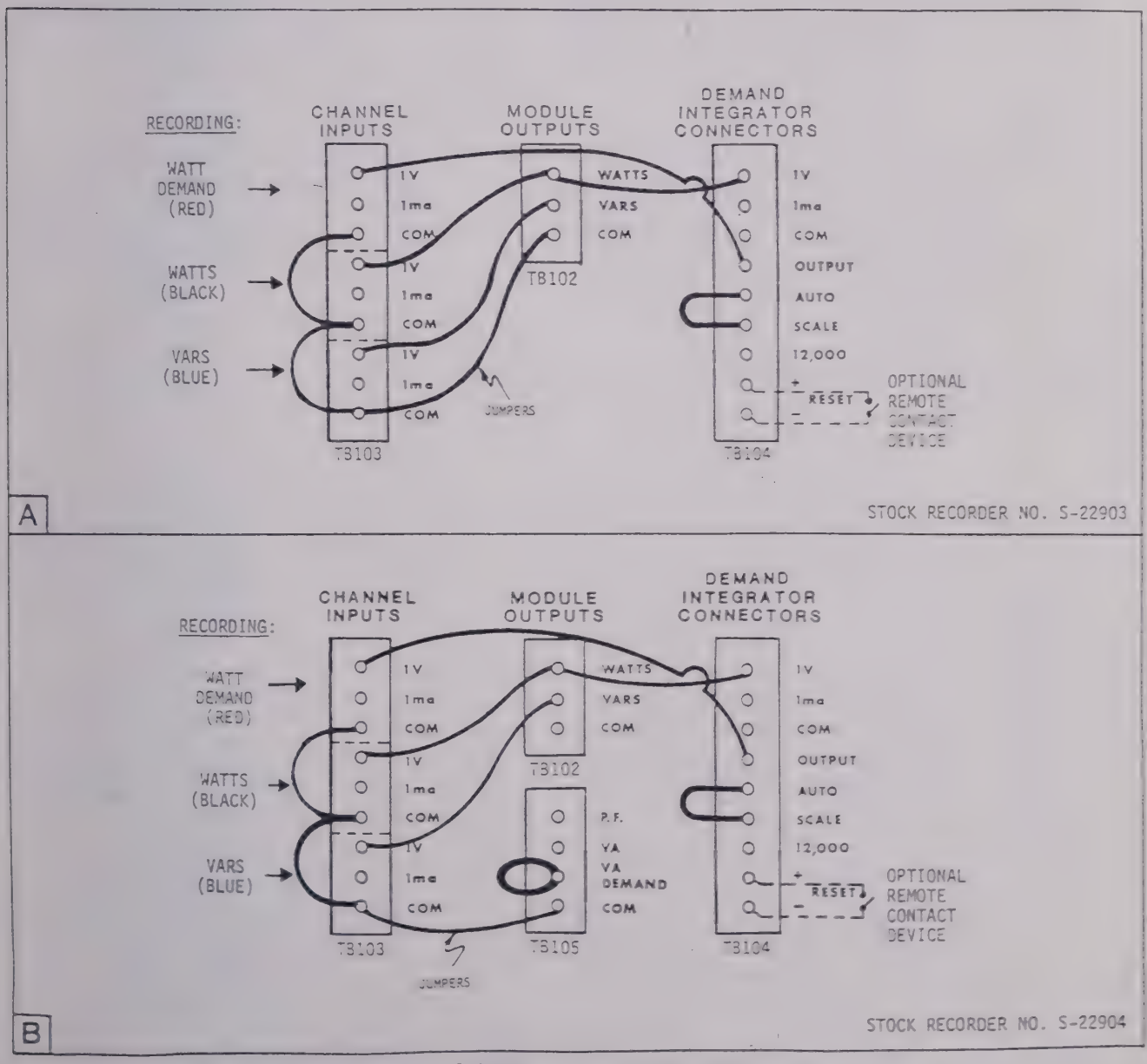


Figure 3-1. Rear-Panel Jumper Wiring for Standard Three-Pen Recorders.

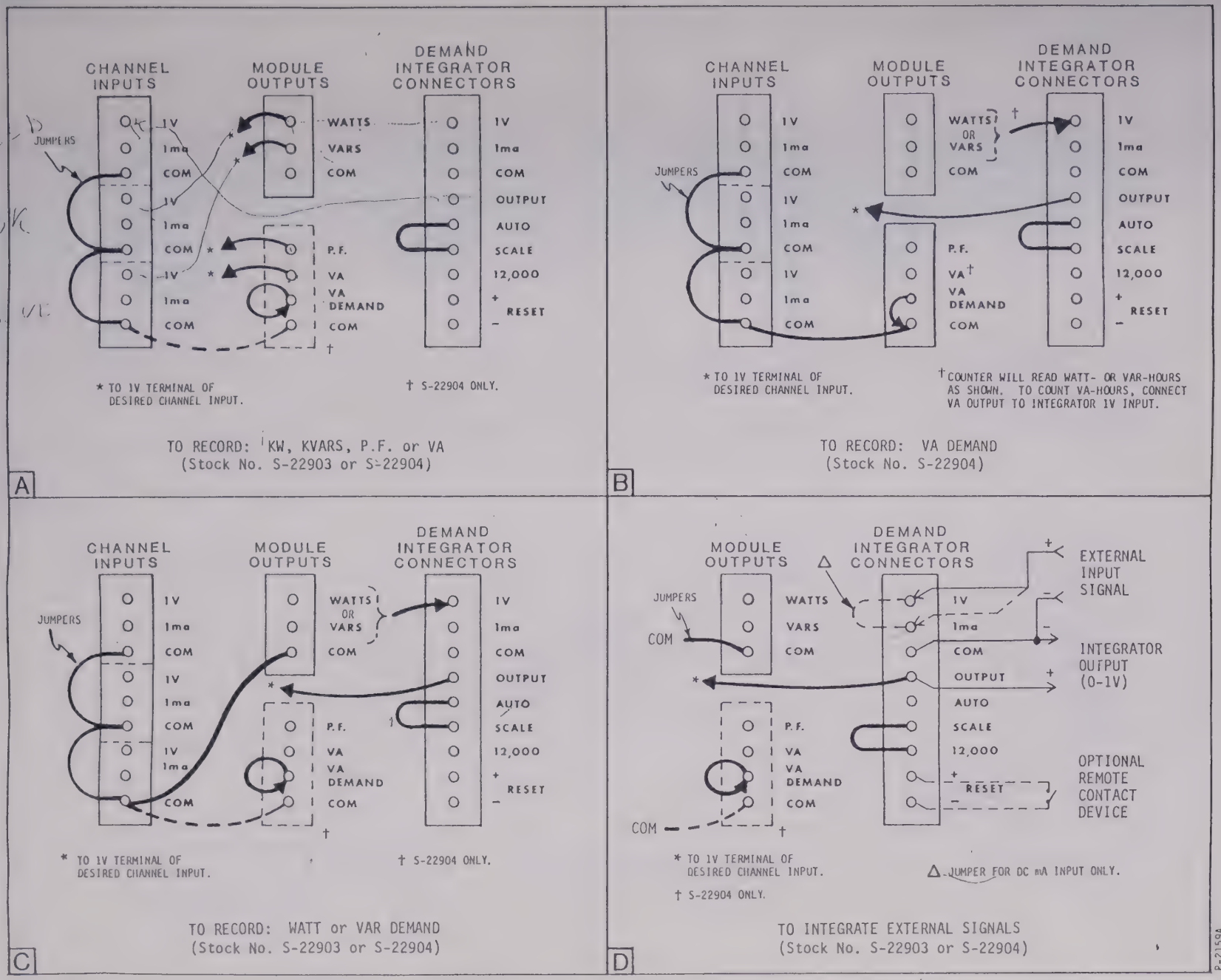
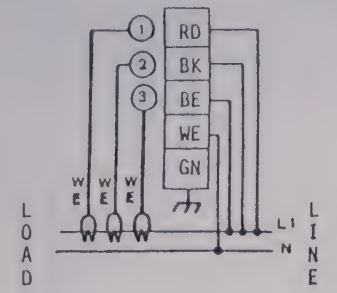


Figure 3-2. Alternate Rear-Panel Jumper Wiring for Three-Pen Recorders.

CIRCUIT 1

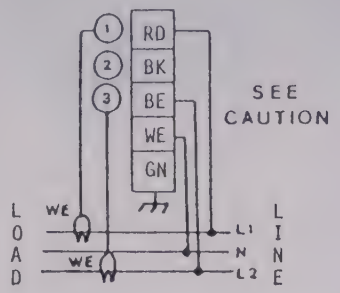
1 Ø, 2 WIRE, UP TO 600V.



ACTUAL VALUES = 1/3 READINGS* (EXCEPT P.F.)

CIRCUIT 2

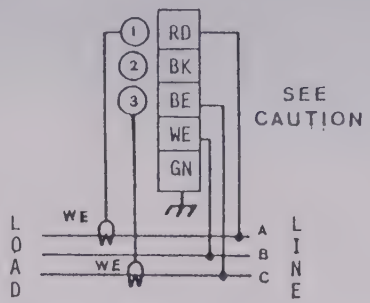
1 Ø, 3 WIRE, 120/240 V.



READINGS CORRECT WHEN USING ONLY TWO ELEMENTS*

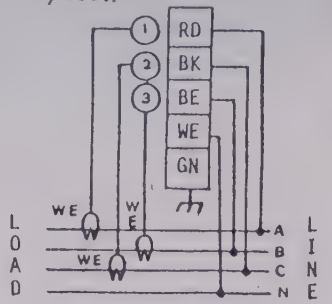
CIRCUIT 3

3 Ø, 3 WIRE, 120-240-480V.



CIRCUIT 4

3 Ø, 4 WIRE "Y" 120/208 277/480V.



READINGS CORRECT*

SYMBOLS:

WE — CURRENT TRANSFORMER (CT). WHITE TERMINAL ALWAYS TO LOAD SIDE OF CT.

VOLTAGE CONNECTION.

LIG — LIGHTING LOAD.

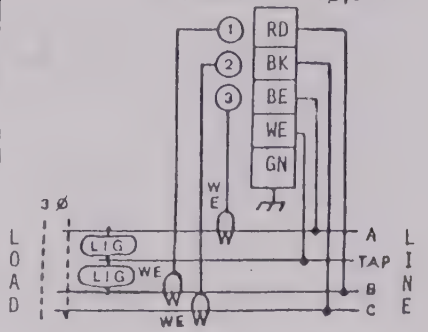
GROUND SHOULD ALWAYS BE CONNECTED TO EARTH GROUND.

CAUTION: CURRENT TRANSFORMER OVERLOADS POSSIBLE- LIMIT = 1000 AMPS. SEE TABLE VALUES FOR CONTINUOUS FULL - SCALE RATING ALLOWABLE FOR 30 MINUTES.

INPUT VOLTS	SELECTED RANGE 1200 KW	600 KW	300 KW
480	1000 KW MAX.	600 KW	300 KW
240	NOT USED	500 KW MAX	300 KW
120	NOT USED	NOT USED	250 KW MAX.

CIRCUIT 5

3 Ø, 4 WIRE DELTA 120V. LIGHT 240V 3 Ø, 3 W.



READINGS CORRECT*

WARNING: ALWAYS FOLLOW STANDARD ELECTRICAL SAFETY PROCEDURES WHEN MAKING CONNECTIONS TO HIGH-VOLTAGE CIRCUITS.

*READINGS INCLUDE BOTH CHART SCALES AND PANEL COUNTER.

F-2160

Figure 3-3. External Connection Diagrams for AC Power Measurements.

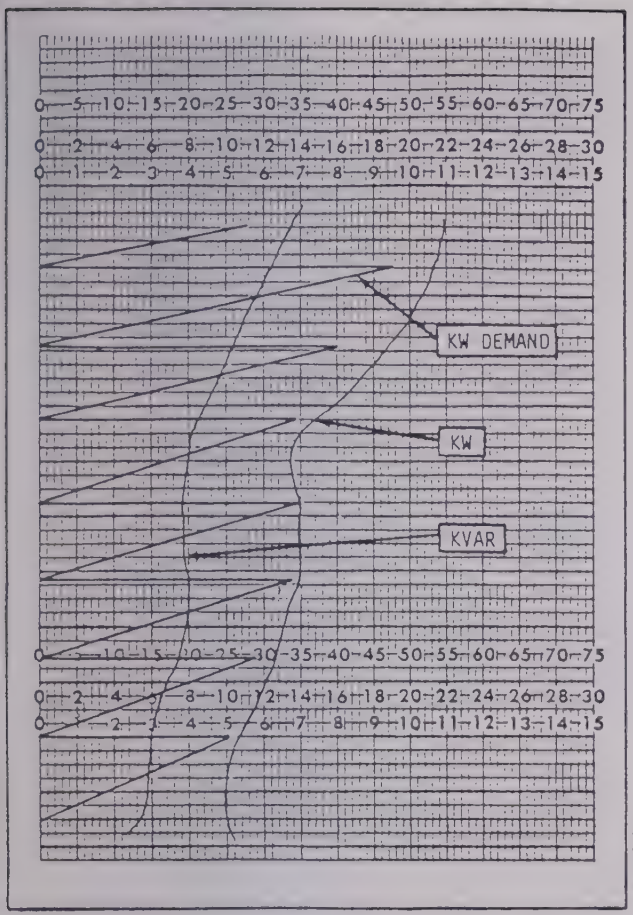


Figure 3-4. Typical Three pen Strip-Chart Record.

3.8 CHART RECORDS

a. Figure 3-4 shows a typical section of strip chart from a recorder measuring three AC power parameters. The parameters shown are kW demand, kW, and kVars. Each will be in a different ink color, depending on recording channels selected.

NOTE: When interpreting chart traces on three-pen units, bear in mind that red pen records 5mm behind black pen, and blue pen records 5mm behind red pen.

b. When recording power factor percentages, remember that pen zero must first be elevated 33.3% of chart span. This point is identified as "1.0" on the power factor scaleplate. If pen remains at chart zero, the recording span will equal lagging power factors of from 1.0 to .25 (or 100% to 25%).

3.9 AC POWER CALCULATIONS

a. The nomograph supplied in Figure 3-5 allows easy calculation of power factor, when kW and kVars are known. To use nomograph, lay a straight edge from kW value to kVar value, as shown by the dotted line. The power factor value for the circuit is read where the line intersects the power factor scale. Both scales (kW and kVar) must be multiplied by the same factor, i.e. 10, 100, 1000, etc.

b. A handy reference table showing the approximate full-load electrical power input for motors of various sizes is given in Table 3-1. These input figures are only approximate because they will vary with the rated speed, line voltage and frequency, and the type of motor. This information may be useful, however, in selecting the proper recorder scale range.

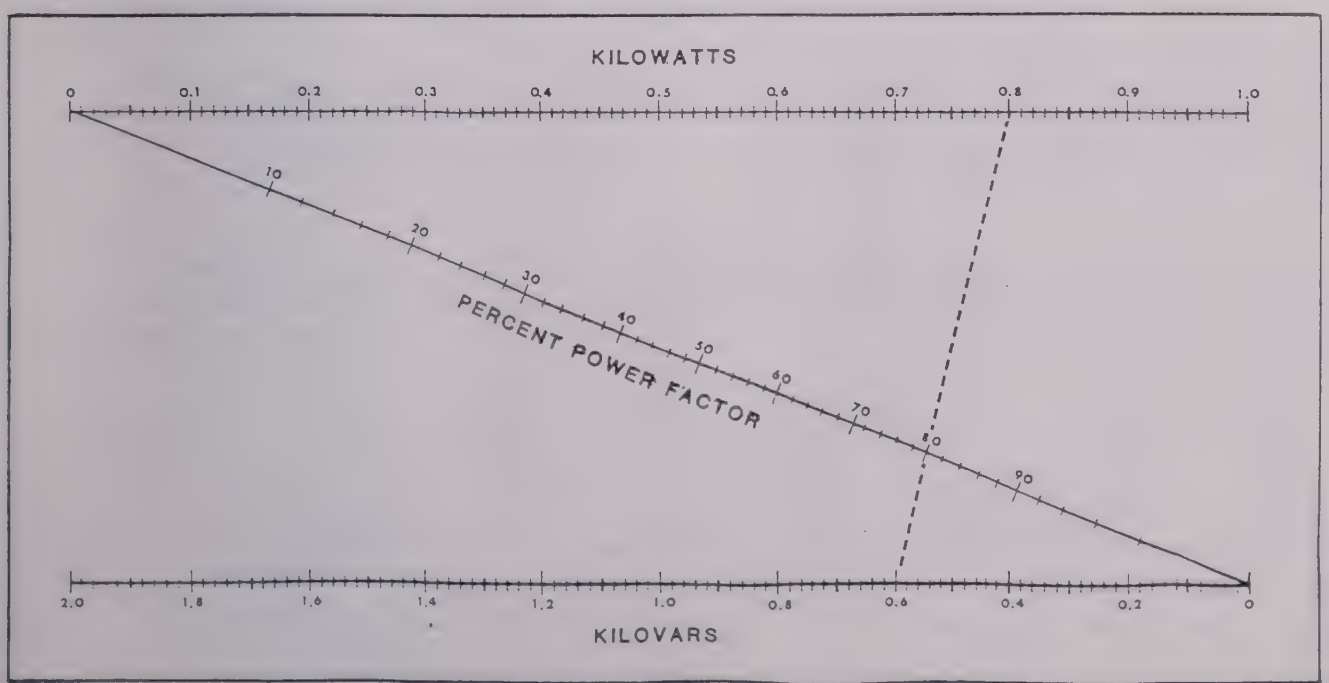


Figure 3-5. Nomograph for Determining Power Factor.

3.10 DC SIGNAL RECORDING

a. All three models of Power Survey Demand Recorders are equipped with rear panel connections to the servo amplifier of the recorder for 0-1V DC and 0-1mA DC inputs. This feature permits the use of various external transducers for recording other parameters such as frequency, temperature, or pressure. Direct channel input connections are shown in Figure 3-6.

b. On three-pen units, additional rear-panel terminals are provided for integration of 0-1V DC or 0-1mA DC signals. In this configuration, full-scale values will equal 12,000 counts. See Figure 3-2D for connections.

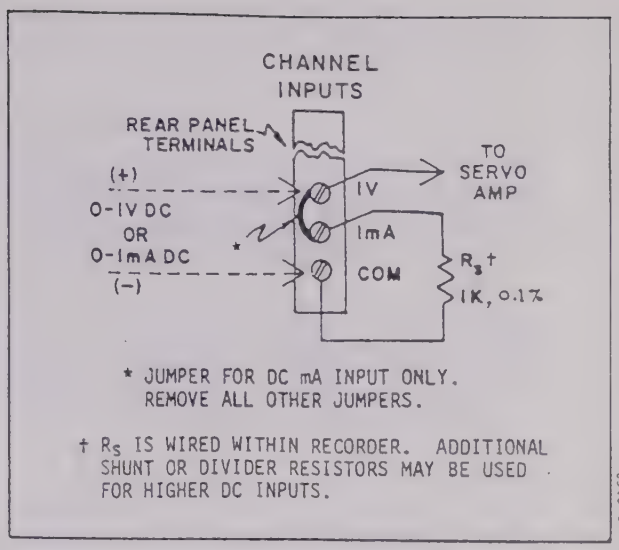


Figure 3-6. DC Analog Connections to Channel Inputs.

4. MAINTENANCE

4.1 GENERAL

a. The Miniservo III Power Survey Demand Recorders are designed for a long, trouble-free life and should require little attention in the field. Periodic maintenance schedules should be established and followed, however, to ensure optimum performance. Where extreme temperature or contaminated atmospheres prevail, maintenance should be performed more often. Since frequency of use and environmental conditions will vary with applications, maintenance scheduling is left to the discretion of the user.

NOTE: Refer to Servicing Documentation manuals for tests and calibration instructions.

b. Routine maintenance procedures will primarily consist of a complete visual inspection, and cleaning. Keeping a simple record of component replacements will be a handy reference during inspection. Items such as chart paper and ink cartridges should be stocked in quantities needed to operate recorder for at least one month.

WARNING: Prior to servicing or cleaning activities, always remove AC power from recorder, and disconnect AC current and potential inputs from external sources.

4.2 INSPECTION

a. A complete visual inspection of the instrument should be made at each scheduled maintenance period to detect the possible onset of a malfunction. At this time, check for low chart and ink supplies, accumulation of dirt, damaged or loose hardware, and shorted or broken wiring.

b. See that all rear-panel connections are clean and tight, replace damaged transformers and worn input leads, and ensure that rear cover is in place during operation.

4.3 CLEANING

a. Regardless of the precautions taken, dirt and dust will enter the recorder chassis area, therefore, periodic cleaning of exposed components will be necessary. Always keep each pen tip free of lint and dried ink. Replace protective cap on each pen tip if recorder will remain inactive for more than 24 hours.

Table 3-1. Typical Motor Power Requirements.

Motor Rating HP	Approx. Full-Load Input KW	Motor Rating HP	Approx. Full-Load Input KW	Motor Rating HP	Approx. Full-Load Input KW	Motor Rating HP	Approx. Full-Load Input KW
⅛	0.25	5	4.4	60	50	400	320
¼	0.3	7½	6.5	75	60	450	360
⅓	0.4	10	8.6	100	80	500	400
½	0.5	15	13	125	100	600	480
¾	0.7	20	17	150	120	700	550
1	0.95	25	21	200	160	750	590
1½	1.4	30	25	250	200	1000	780
2	1.8	40	34	300	240	1250	980
3	2.7	50	42	350	280	1500	1175

The electrical input values are based on the following average full load efficiency figures:

½HP, 65%; 1 HP, 79%; 3 HP, 83%; 10 HP, 86%; 30 HP, 88%; 100 HP, 91%; 300 HP, 93%; 1000 HP, 95%. 1 HP = 0.746 KW.

b. Light dirt marks can be removed from case and transformer surfaces, scaleplate, and front control panels with a damp cloth or sponge. Esterline Angus recording ink is water-based and can be removed with a wet cloth. Heavier dirt smudges can be removed with any commercially available liquid detergent; however, DO NOT use harsh solvents as they may damage certain finishes.

CAUTION: Exercise care when cleaning to avoid disturbing electrical wiring and alignment of mechanical parts.

4.4 LUBRICATION

All mechanical friction surfaces, motors, and other moving parts of the recorder are permanently lubricated at the factory; therefore, no further lubrication is required for maintenance purposes.

4.5 REPLACEMENT PARTS

a. The replacement parts listed in Table 4-1 include only those external items and accessories that an operator can replace easily in the field. For a complete parts breakdown of the instrument, refer to Servicing Documentation covering Power Survey Recorders.

b. Most parts and recording supplies are available through Esterline Angus Sales Offices. To ensure prompt delivery and receipt of parts, always mention instrument Model Number and Serial Number as well as part number and description of all items desired.

Table 4-1. Condensed Replacement Parts List.

ITEM REF.	PART NUMBER	DESCRIPTION	QUANTITY
	**	Accessory Kit (Complete w/. indented items)	1
T301	752C427	.Transformer, Clamp-On Current (0-1000A)	3
	804C511-1	.Cable, Current Input; coded Red	1
	804C511-2	.Cable, Current Input; coded Black	1
	804C511-3	.Cable, Current Input; coded Blue	1
	804C510-1	.Lead, Potential Input; Red	1
	804C510-2	.Lead, Potential Input; Black	1
	804C510-3	.Lead, Potential Input, Blue	1
	804C510-4	.Lead, Potential Input, White	1
	59323-T100	.Pack, Chart (6 charts)	1
	723A26-6	.Pen Kit, Red (6 pens); 1-pen model only.	1
	752A900-1-6	.Pen Kit, Blue (6 pens); 3-pen models only.	1
	752A900-2-6	.Pen Kit, Red (6 pens); 3-pen models only.	1
	752A900-3-6	.Pen Kit, Black (6 pens); 3-pen models only.	1
	M804D12-14	.Manual, Operating Instructions	1
	752A538	.Fuse Kit	1
	752A907*	.Ink Cartridge, Event Pen (Specify)	A/R
	¶	Scaleplate	1
	723A54	Foot Rest; 1-pen model only.	4
	190169-2	Foot Rest, Right; 3-pen models only.	1
	190169-1	Foot Rest, Left; 3-pen models only.	1
	45024	Foot Rest, Rear; 3-pen models only.	2
	190169-5	Tilt Bail(Bar); 3-pen models only.	1
	723A63	Knob, RANGE KW/KVAR Switch	1
	723A63	Knob, Chart Drive Speed Selector	1
	723A64	Handle, Chassis Case; 1-pen model only.	1
	723A64	Handle, Chassis Case; 3-pen models only.	2
	804B518 ⊕	Cover Assy., Rear Panel; 1-pen (less labels)	1 A/R
	804B519 ⊞	Cover Assy., Rear Panel; 3-pen (less labels)	1 A/R
	804B679	Label, Cover (Connection)	1
	804A630	Label, Cover (Danger)	1
CT	804D918*	Transformer, Clamp-On Current (0-2000, 3000A)	1 A/R
CT	804B908*	Transformer, Clamp-On Current (0-150A)	1 A/R
	804D900*	Case, Carrying; 3-pen models only.	1 A/R
	804C901*	Case, Carrying; 1-pen model only.	1 A/R
	M804D12-14S*	Manuals, Servicing Documentation	1 Set

** - Part No. 804A907 for S-22905, 804A905 for S-22903 and S-22904. Add-1 for Event Pen.
¶ - Part No. 723A55-269 for S-22905, 804A653 for S-22903, 804A652 for S-22904.
⊕ - Hinge type. For screw-type mounting with labels order Cover #804B515 (Screw #804A639).
⊞ - Hinge type. For screw-type mounting with labels order Cover #804B514 (Screw #804A639).
* - Optional Item.
A/R - As Required.

APPENDIX - RECORDER OPTIONS

A1. ALARM ATTACHMENTS

A1.1 DESCRIPTION

a. Each alarm option available for Miniservo® III Power Survey Recorders provides the means of detecting one high or one low alarm. This alarm condition occurs whenever the pen of a recording channel having the alarm option passes through the alarm setpoint in the desired direction. An alarm condition results in a DPDT relay actuating one set of rear-panel output terminals (NO, NC, and COM) per recorder channel so equipped. Three-channel recorders may have up to three relays and three sets of output terminals. See Figure A1-2 for terminal location.

b. One light-emitting diode (LED) indicator and one setpoint adjustment (Figure A1-1) are provided for each recording channel having the alarm option, and are located at the top of a specific recorder module. The exact location of this indicator and adjustment depends on the number of recording channels to be alarm-equipped. Refer to Table A1-1 for typical alarm adjustment locations.

NOTE: In 3-pen models, power parameters related to alarm circuits will, of course, depend upon rear-panel jumper wiring.

c. The LED indicator comes on and the output terminals are actuated when the proper recording pen passes through the alarm setpoint for that channel, in the desired direction. For example, if a high alarm is set at 80% of chart span for the red pen, an alarm condition will exist if the pen moves from 70% of chart span to 85%. If the pen moves back to 70% of chart span, an alarm condition no longer exists. If, on the other hand, a low alarm is set for 40% of chart span, an alarm condition exists if the pen drops below this point.

d. The alarm setpoint adjustment, also shown in Figure A1-1, allows placing the setpoint anywhere along the active chart span. A colored dot to the right of this adjustment indicates for which recording pen the setpoint adjustment is being made. A separate Alarm Relay Board (mounted internally) contains a relay and set of output terminals for each recording channel having the alarm option. Each set of three terminals consists of one normally closed (NC), one normally open (NO), and one common (COM) terminal. These are connected to the corresponding relay

Table A1-1. STANDARD ALARM/PEN RELATIONSHIPS.

ALARM NUMBER	ALARM ADJ. LOCATION	PEN COLOR
1st	Watt/Var Module	Red
2nd	Demand Integ. Module	Blue
3rd	PF/KVA Module*	Black

*For S-22903 recorder, third alarm is at top of blank center module position.

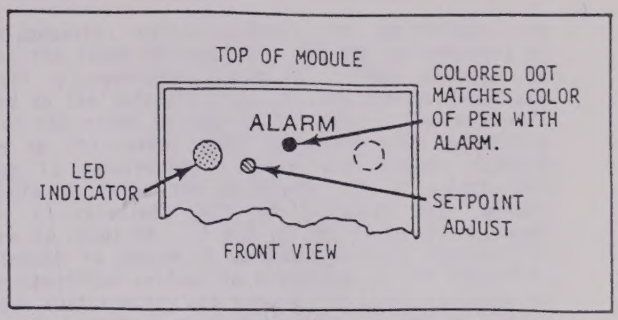


Figure A1-1. Location of Indicator and Adjustment.

contacts, and are used to control the "on" or "off" condition of external alarm circuitry.

NOTE: For optional 3-pen alarm wiring configurations, refer to separate Servicing Documentation.

A1.2 ALARM SETPOINT ADJUSTMENT

The alarm setpoint for each recording channel so equipped can be adjusted without the use of external voltage or current sources. Use the following procedure for adjusting setpoint:

(1) Place instrument main POWER switch in OFF position. Observe top of recorder modules or refer to Table A1-1 to determine which recording channels are equipped with the alarm option.

(2) On three-pen recorders, gain access to recorder rear panel to verify that desired AC parameters are connected to recording channels having alarm option. One, two, or all three channels may be so equipped. On one-pen recorders, make sure Recording Mode Switch on rear panel is in either the WATT or VAR position, as desired. To expose rear panel on either type of recorder, turn the retaining screw(s) located along top of rear panel cover three-quarters of a turn counterclockwise, then remove cover.

WARNING: Hazardous potentials may be present on rear-panel terminal block labeled VOLTAGE INPUTS when external AC source connections are made.

(3) If proper connections have not been made on three-pen recorder rear panel, refer to OPERATION section of this manual.

(4) Place instrument main POWER switch in ON position and RANGE Selector Switch on Watt/Var Module to OFF/ZERO position. Locate ZERO ADJUST screw, (above scaleplate) with colored dot corresponding to color of recording pen to be adjusted. Turn ZERO ADJUST to place pen at desired alarm setpoint location on chart.

(5) Turn matching color-coded setpoint adjustment until LED indicator just comes on. Readjust ZERO ADJUST screw to place pen back to original location. Repeat for other pens, if supplied and equipped with alarm option.

(6) After adjustments are complete, connect external alarm circuits to Alarm Relay Board output terminals. See following paragraph for connection details.

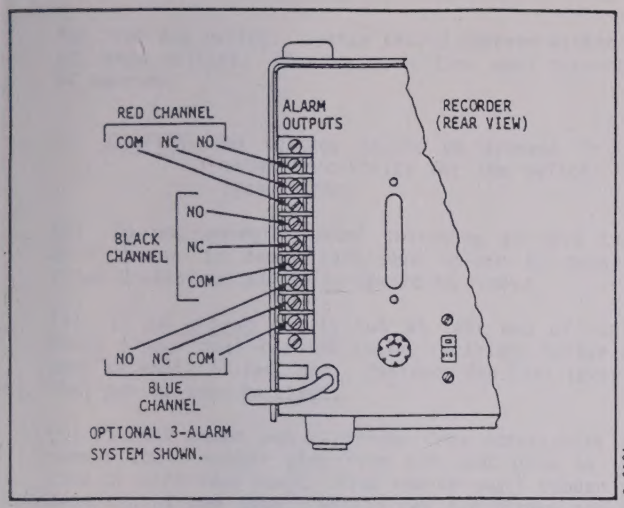


Figure A1-2. Location of Output Terminals.

A1.3 ALARM OUTPUT CONNECTIONS

a. External alarm circuits to be actuated by an alarm condition on a particular recording channel are connected to the appropriate terminals of the terminal block labeled ALARM OUTPUTS. This terminal block, shown in Figure A1-2, is located on the recorder rear panel. Each recording channel having the alarm option has one set of three output terminals labeled NO-normally open, NC-normally closed, and COM-common. The terminals are also labeled with the recording channel pen color. Relay contacts on Alarm Relay Board are rated 2A @ 115V AC.

b. In order to make external alarm circuit connections, gain access to rear panel by turning the retaining screw(s) located along the top of rear panel cover three-quarters of a turn counterclockwise, then remove cover. If a high alarm is desired, connect external circuit to the NO and COM terminals. Connect to the NC and COM terminals for low alarm actuation. Use AWG No. 22 or larger wire for connection to ALARM OUTPUTS terminal block. After external connections have been made, secure rear panel cover.

NOTE: For internal wiring diagrams and replacement parts, refer to separate Servicing Documentation manuals.

A2. EVENT PEN ATTACHMENTS

A2.1 DESCRIPTION

a. All Miniservo III Power Survey Recorders can be equipped with an Event Pen attachment. This option is designed to record event information by graphically indicating the time of occurrence and duration of external "on-off" signals. The system features a separate inking pen that records in the right-hand margin of the chart paper. The event pen is time-aligned on the chart with the red analog pen, but all analog electrical circuits are completely isolated from the event pen circuit. External connections are provided on the rear panel of the recorder, as shown in Figure A2-1.

b. Disposable, self-contained, ink cartridges are used in the Event Pen option. The pen is actuated by a small plunger-type solenoid. When voltage is applied to the solenoid circuit, the pen is displaced .04" to the right on the chart paper. The pen will return to its normal "off" position when actuating voltage is interrupted. There are several methods available to drive the solenoid. If a switch-type option is selected, only an external dry contact closure is required. If one of the AC or DC voltage-type inputs is chosen, a solenoid circuit appropriate to the specified voltage is installed in the recorder. The user must specify and supply the input voltage, as well as the external event switching mechanism. Refer to instrument Data Sheet for type or input rating supplied.

A2.2 OPERATING PROCEDURE

The event pen option is made functional by wiring external switching circuitry to the recorder, installing ink cartridge, and energizing the system. Proceed with the following steps:

(1) Unpack items from accessory kit, make sure that all shipping materials have been removed from recorder, and remove instrument power.

(2) Connect external event circuit to rear terminals of recorder as shown in Figure A2-1. See Data Sheet

Table A2-1. Event Pen Specifications.

EVENT SYSTEM	Provides continuous ON- OFF records of external event signals.
INPUT ACTUATION (Optional):	
AC Ratings	120 or 240 volts rms (±10%).
DC Ratings	6, 12 or 24 volts (±10%).
Switch Type	Dry contact closure. Internal voltage source supplied.
SIGNAL RESPONSE:	
Pulse Width (ON or OFF)	125 msec. minimum for full deflection.
Repetition Rate	4 Hz maximum @ 50% duty cycle.
RECORDING METHOD	Disposable ink cartridge with nylon pen tip. Trace length approx. 365 meters.
PEN ACTUATION	Push-type, continuous-duty, solenoids. Approx. 3 watts.
PEN DISPLACEMENT	1mm (.04") minimum @ rated input.
INPUT CONNECTIONS	Two terminals provided at rear of recorder. Voltage divider supplied for 240V AC operation.